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SPECIFICATION FOR GENERAL PURPOSE WAVEGUIDE DIRECTIONAL COUPLERS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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March 1986

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SPECIFICATION FOR GENERAL PURPOSE WAVEGUIDE DIRECTIONAL COUPLERS

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SPECIFICATION FOR GENERAL PURPOSE WAVEGUIDE DIRECTIONAL COUPLERS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 31 May 1985, after the draft finalized by the Microwave Components and Accessories Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 While preparing this standard, assistance has been derived from JSS 53200 : General requirements for couplers, directional coaxial line or waveguide issued by the Ministry of Defence.

0.3 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This specification covers the requirements for general purpose waveguide directional couplers.

2. TERMINOLOGY

2.0 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part 56)-1981† shall apply in addition to the following.

2.1 Uni-directional Coupler — It is a directional coupler so designed as to provide a nominal response in the auxillary line to propagation in the main line, in one direction only.

2.2 Bi-directional Coupler, Dual Directional — It is a directional coupler so designed as to provide separate and simultaneous nominal responses in

---

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary: Part 56 Microwave components and accessories.

the auxillary lines to each of the two directions of propagation in the main line.

2.3 Cross Guide Directional Coupler — These directional couplers are the units containing appropriate coupling apertures in the broad wall junction.

2.4 Multihole Directional Coupler — These directional couplers consist of a main and an auxillary line with a common broad wall or narrow wall containing the coupling holes.

2.5 Mid Frequency — The mid frequency of a directional coupler is defined as the arithmetic mean of the limits of its frequency range.

2.6 Main Line — The main line of a directional coupler is the line designed to receive the principal flow of RF energy in the transmission line to which the directional coupler is adjunct. The input end of the main line of a uni-directional coupler is the end into which power must flow in order to produce the maximum power at the output of the auxillary line. The other end is called the output (antenna) end.

2.7 Auxillary Line — The auxillary line of a directional coupler is the line that is coupled to the main line by means of the coupling structure. In a uni-directional coupler there is one auxillary line. In a bi-directional coupler the auxillary lines have a nominal response to a different direction of propagation in the main line. In some bi-directional couplers the auxillary lines are physically separate, in others they run physically together.

3. MATERIAL, PROCESSES AND FINISHES

3.1 Materials — The directional couplers shall be made using materials specified in **4.1** of IS : 4493 (Part 1)-1979*. (*See also* Appendix A.)

3.2 Design and Construction — Directional couplers shall be designed and constructed to confirm to the requirements specified in a manner entirely suitable for their intended use.

3.2.1 *Flanges* — Flanges shall be so designed and manufactured as to provide the mating characteristics of the flange specified.

3.2.2 *Caps* — Weatherproof caps shall be attached to the directional coupler by means of small, flexible, corrosion-resistant chains.

3.3 Finish — All metal parts of directional couplers which are not corrosion-resistant shall be plated. External finish shall be applied to the directional couplers regardless of plating or chemical treatment, except

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*Specification for hollow metallic waveguides: Part 1 General requirements and tests (*first revision*).

that the mating surfaces shall not be coated. External coatings shall be applied as continuous films.

3.4 Workmanship — Directional couplers shall be manufactured and processed in such a manner as to be uniform in quality, and free from other defects that will affect life, serviceability or appearance.

3.4.1 *Cleaning* — After fabrication, directional couplers shall be cleaned of smudges, loose, spattered or excess solder, weld metal, metal chips, mould release agents or any other foreign material which might detract from the intended function or appearance. (This would include any particles that would loosen or become dislodged during the normal expected life.) All corrosive material shall be removed.

3.4.2 *Threaded Parts* — Screws, nuts and bolts shall show no evidence of cross threading and detrimental or hazardous burrs.

3.4.3 *Welding* — All welds shall be free of harmful defects, such as cracks, porosity, undercuts, voids and gaps. There shall be no burn through. Fillets shall be uniform and smooth. Angular or thickness misalignment, warpage or dimensional change due to heat from the welding operation shall be within the permitted tolerances. There shall be no damage to adjacent parts resulting from the welding.

4. MARKING

4.1 Each directional coupler and its package shall be legibly and indelibly marked in the location specified in the preferred order shown below:

a) Manufacturer's code and date,
b) Coupling factor (nominal value in dB) with frequency range, and
c) Directivity at mid frequency.

4.2 Marking shall be applied directly on the coupler or on an attached name plate. On uni-directional couplers, an arrow (or other indication) shall be placed in the direction in which coupler power flows. On bi-directional couplers which have two different couplings, the coupling of each auxillary line shall be indicated separately in a manner that will make clear which coupling is associated with each auxillary line. Bi-directional couplers shall be marked to indicate which of the auxillary lines has a nominal response to each direction of incident power flow.

4.3 The method of marking shall not be detrimental to the performance of the directional coupler.

5. PACKAGING

5.1 Directional couplers shall be preserved and packed in a manner that will afford adequate protection against corrosion, deterioration and physical damage during transit from the supply source to the first receiving activity.

6. TESTS

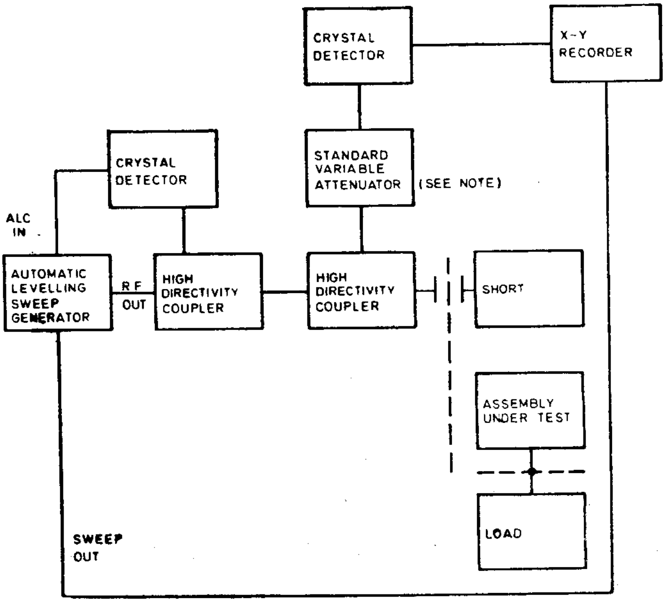
6.1 Coupling Factor — The coupling factor of directional couplers shall be determined at mid frequency in the specified frequency range. It shall be determined as the ratio, expressed in dB, of the power input to the main line and the power available at the output of the auxillary line, with output end of the main line properly terminated, when the incident power is in the direction of excitation of the main line that will produce the maximum response in the auxillary line. The coupling factor of bi-directional couplers shall be determined separately for each auxillary line. The coupling variation of directional couplers shall be determined over the specified frequency range. The coupling variation of uni-directional couplers shall be determined by taking the difference between the maximum and minimum coupling over the specified frequency range. Such difference shall be taken as a positive number if it exceeds the nominal value or negative number if it is less than the nominal value. The coupling variation of bi-directional couplers shall be determined separately for each auxillary line.

6.2 Directivity — The effective directivity of the directional couplers shall be determined over the specified frequency range. It should be computed from the ratio, taken as greater than unity and expressed in dB, of the available powers at the output of the auxillary line for the two directions of excitation, at equal power levels, of the main line; the auxillary line shall be terminated in a matched detector. The effective directivity of bi-directional couplers shall be determined separately for each auxillary line.

6.2.1 *Alternate Test* — The effective directivity of directional couplers over the specified frequency range shall be computed from the difference between the measurements of minimum and maximum outputs of an auxillary line, when a short circuit is displaced through one-half a wavelength in the main line. The generator at the main line shall be matched to the main line. The effective directivity of bi-directional couplers shall be determined separately for each auxillary line with the remaining auxillary lines terminated by an impedance equal to the characteristic impedance of the auxillary line.

6.3 Voltage Standing Wave Ratio (VSWR)

6.3.1 *Main Line* — The VSWR of directional couplers shall be measured over the specified frequency range as shown in Fig. 1. The VSWR of uni-directional couplers shall be measured at the input end of the main line, with the output end of the main line and the auxillary line terminated in



NOTE — Use 20 dB pad when calibration is for coaxial end measurements then remove.

FIG. 1 VSWR TEST SET UP

matched loads. The VSWR of bi-directional couplers shall be measured at one end of the main line, with the other end terminated in a matched load; the auxillary lines shall be terminated in matched loads.

6.3.2 *Auxillary Line* — The VSWR of directional couplers shall be measured over the specified frequency range. The VSWR of uni-directional couplers shall be measured at the output of the auxillary line with both ends of the main line terminated in matched loads. The VSWR of each auxillary line of bi-directional couplers shall be measured at the output of the auxillary line with the other auxillary line and both ends of the main line terminated in matched loads.

6.4 Insertion Loss — The insertion loss shall be measured by a substitution technique using radio, audio or intermediate frequency (RF, AF or IF) as in Fig. 2. An average of three test runs shall be used as a final result.

6.5 Power Dissipation of the Auxillary Line Termination — The power dissipation of the auxillary line termination shall be determined over the

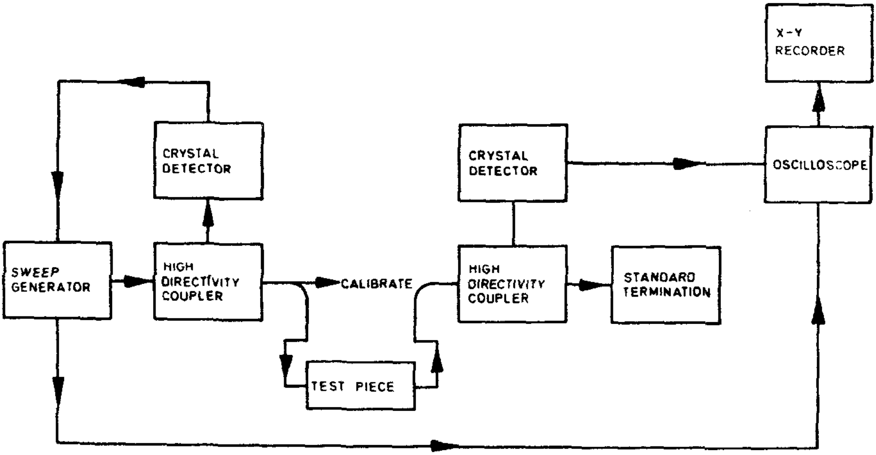


FIG. 2 TEST SET UP FOR INSERTION LOSS

specified frequency range. The power (P_1) to be applied shall be determined from the following formula:

$$P_1 = \frac{P_0}{\log_{10}^{-1} \frac{\alpha}{10}}$$

where

P_1 = power to be applied,

P_0 = continuous wave power rating of the primary line, and

α = coupling factor in dB.

The power (P_1) shall be applied for a period of one hour to the output of the auxillary line, with both ends of the main line terminated in matched loads. Within 3 minutes after the one hour period, the VSWR of the auxillary line shall be measured as in **6.3** at mid frequency in the specified frequency range.

6.5.1 *Alternate Test* — The power dissipation of the auxillary line termination shall be determined over the specified frequency range. Rated continuous wave power shall be applied for a period of one hour to the input end of the main line, with the output end of the main line and the output of the auxillary line terminated in matched loads. After the one hour period, the VSWR of the auxillary line shall be measured at mid frequency in the specified frequency range.

6.6 Pressurization Test — Directional couplers shall be subjected to an internal air pressure as specified for a period of at least 20 seconds while immersed in tap water at standard temperature. Where no limits are specified the internal air pressure shall be 207 kPa. The ends of the main line shall be appropriately sealed. During immersion the directional couplers shall be observed for evidence of leakage as indicated by escaping air bubbles.

6.7 Change of Temperature

6.7.1 Directional coupler shall be subjected to the temperature cyclic test as specified in procedure I of IS : 9000 (Part 14/Sec 1)-1978* with the following severities:

Temperature	–10°C to +55°C
Duration	30 minutes
Transfer time	10 to 15 minutes

The specimen shall be visually examined. There shall be no evidence of damage.

6.8 Damp Heat Cyclic Test

6.8.1 Directional coupler shall be subjected to the damp heat cyclic test as specified in IS : 9000 (Part 5)-1978†. The specimen shall be visually examined. There shall be no evidence of damage.

6.9 Vibration Test

6.9.1 Directional coupler shall be subjected to the vibration test as specified in IS : 9000 (Part 8)-1981‡ with the following severities:

Frequency	10 to 55 Hz
Amplitude	0·75 mm or 10 g
Number of sweep cycles	10
Method	Endurance by sweeping

Couplers shall be attached to the vibration table by means of clamps. A clamp shall be placed around the centre of each coupler and no part of the coupler shall touch any object other than the clamp.

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*Basic environmental testing procedures for electronic and electrical items: Part 14 Change of temperature, Section 1 Rapid change of temperature by two-chamber method.

†Basic environmental testing procedures for electronic and electrical items: Part 5 Damp heat (cyclic) test.

‡Basic environmental testing procedures for electronic and electrical items: Part 8 Vibration (sinusoidal) test.

6.9.2 The specimen shall be visually examined. There shall be no evidence of damage.

6.10 Corrosive Atmosphere (Salt Mist)

6.10.1 Directional coupler shall be subjected to the corrosive atmosphere test as specified in procedure 1 of IS : 9000 (Part 11)-1983*. The duration of the tests shall be 96 hours. The couplers shall be sealed at the flanges during the test. After the test, the couplers shall be washed, dried and examined for destructive corrosion or pitting. There shall be no destructive corrosion or pitting.

7. GENERAL REQUIREMENTS

7.1 The characteristics, the method of measurement and the requirements to be met are given in Table 1.

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*Basic environmental testing procedures for electronic and electrical items: Part 11 Salt mist test.

TABLE 1 TEST SCHEDULE

(*Clause* 7.1)

Sl No.	Test	Method of Measurement (Ref to Clause)	Requirement	
			Waveguide Multihole Directional Coupler	Waveguide Cross Directional Coupler
(1)	(2)	(3)	(4)	(5)
1.	Visual examination	The specimen shall be visually examined	The condition, workmanship, finish and markings shall be satisfactory	The condition, workmanship, finish and markings shall be satisfactory
2.	Coupling factor and coupling variation:	6.1	3 dB, 10 dB, 20 dB ±0·5 dB	20 dB ±1 dB
	a) Mean coupling accuracy	—	±0·4 dB (±0·7 dB for K-Band)	±0·5 dB
	b) Frequency sensitivity	—	—	± 1·3 dB
3.	Directivity	6.2	40 dB (*Min*)	20 dB (*Min*)
4.	Voltage standing wave ratio (VSWR) or return loss	6.3	Main arm (*Max*) 1·05 (1·1 for 3 dB coupler) Side arm (*Max*) 1·15 (1·2 for K-band and above)	Main arm (*Max*) 1·05
	a) Frequency range	—	8·2 to 12·4 GHz 12·4 to 18·0 GHz 18·0 to 26·5 GHz	2·6 to 3·95 GHz 5·8 to 8·2 GHz 18·0 to 26·5 GHz
5.	Insertion loss	6.4	Under consideration	—

(*Continued*)

TABLE 1 TEST SCHEDULE — *Contd*

SL No.	TEST	METHOD OF MEASUREMENT (Ref to Clause)	REQUIREMENTS	
			Waveguide Multihole Directional Coupler	Waveguide Cross Directional Coupler
(1)	(2)	(3)	(4)	(5)
6.	Power dissipation of secondary line termination	6.5	The VSWR of the secondary line at mid frequency of the specified frequency range shall be as specified in Sl No. 4	The VSWR of the secondary line at mid frequency of the specified frequency range shall be as specified in Sl No. 4
7.	Pressurization	6.6	There shall be no leakage as detected by the formation of escaping air bubbles	There shall be no leakage as detected by the formation of escaping air bubbles
8.	Change of temperature	6.7	6.7	6.7
9.	Damp heat cyclic	6.8	6.8	6.8
10.	Vibration	6.9	6.9	6.9
11.	Corrosive atmosphere (salt mist) (optional)	6.10	6.10	6.10

APPENDIX A

(*Clause* 3.1)

TECHNICAL INFORMATION

A-1. TECHNICAL NOTES

A-1.1 Dissimilar metals, between which an electromotive couple may exist, shall not be placed in contact with each other.

A-2. INTERMETALLIC CONTACT

A-2.1 The finishing of metallic areas to be placed in intimate contact by assembly presents a special problem, since intermetallic contact of dissimilar metals results in electrolytic couples which promote corrosion through galvanic action. To provide the corrosion protection required in ground signal equipment, intermetallic couples shall be restricted to those permitted by Table 2. Table 2 shows metals and alloys (or plated) by groups which have common electromotive forces (EMF) within 0·05 volt when coupled with a saturated calomel electrode in sea-water at ordinary room temperatures. All members of a group are considered as completely compatible, one with the other. Compatible couples between groups have been specified in Table 2 based on a potential difference of 0·25 volt maximum. To simplify any arithmetic involved, Table 2 shows, in addition to EMF against a calomel electrode, a derived 'anodic index' with Group 1 (gold, etc) as 0 and Group 18 (magnesium, etc) as 175. Substraction of a lower group anodic index gives the EMF difference in hundredths of a volt.

A-2.1.1 *Groups* — Table 2 sets up 18 primary groups. It may be noted that neither the metallurgical similarity or dissimilarity of metals is the parameter for selection of compatible couples. All members within a group, regardless of metallurgical similarity, are considered inherently non-susceptible to galvanic action when coupled with any member within the group; for example, such dissimilar metals as platinum and gold. Similarly, such basically dissimilar alloys as austenitic stainless steel, silver-solder, and low brass (all members of Group 5) are inherently non-susceptible when coupled together.

A-2.1.2 *Compatibility Graphs* — Permissible couple series are shown in Table 2 by the graphs at the right. Members of groups connected by lines will form permissible couples. A '○' indicates the most cathodic member of each series, a '●' an anodic member, the arrow the anodic direction.

TABLE 2 COMPATIBLE COUPLERS
(*Clause* A-2.1.1)

GROUP	METALLURGICAL CATEGORY	EMF (VOLT)	ANODIC INDEX (0·01 V)	COMPATIBLE COUPLE (*See* NOTE BELOW)
1	Gold, solid and plated; gold platinum alloys; wrought platinum	+0·15	0	○
2	Rhodium plated on silver plated copper	+0·05	10	●○
3	Silver, solid or plated; high silver alloys	0	15	●●○
4	Nickel, solid or plated; monel metal, high-nickel-copper alloys	−0·15	30	●●○
5	Copper, solid or plated; low brasses or bronzes, silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion-resistant steels	−0·20	35	●●●○
6	Commercial yellow brasses and bronzes	−0·25	40	●●●○
7	High brasses and bronzes; naval brass; Muntz metal	−0·30	45	●●●○
8	18 percent chromium type corrosion-resistant steels	−0·35	50	●●●●○
9	Chromium, plated; tin, plated 12 percent chromium type corrosion-resistant steels	−0·45	60	●●●●○
10	Tin-plated; ternoplate; tin-lead solder	−0·50	65	●●●●○
11	Lead, solid or plated; high lead alloys	−0·55	70	●●●●○
12	Aluminium, wrought alloys of the duralumin type	−0·60	75	●●●●○
13	Iron, wrought, grey, or malleable; plain carbon and low alloy steels, armco-iron	−0·70	85	●●●●○
14	Aluminium, wrought alloys other than duralumin type; aluminium, case alloys of the silicon type	−0·75	90	●●●●○
15	Aluminium, cast alloys other than silicon type; cadmium, plated and chromated	−0·80	95	●●●●○
16	Hot-dip-zinc plate; galvanized steel	−1·05	120	●○
17	Zinc, wrought; zinc base die-casting alloys; zinc, plated	−1·10	125	●
18	Magnesium and magnesium-base alloys, cast or wrought	−1·60	175	●

NOTE — ○ = Indicates the most cathodic members of the series
● = Indicates an anodic member.
Arrows indicate the anodic direction.

A-2.1.3 *Selection of Compatible Couples* — Proper selection of metals in the design of equipment will result in fewer intermetallic contact problems. For example, for sheltered, exposure neither silver nor tin required protective finishes. However, since silver has an anodic index of 15 and tin 65 the EMF generated as a couple is 0·50 volt which is not allowable by Table 2. In this case, other metals or plates will be required. It should be noted that, in intermetallic couples, the member with the higher anodic index is anodic to the member with the lower anodic index and will be susceptible to corrosion in the presence of an electrolytic medium. If the surface area of the cathodic part is significantly greater than that of the anodic part the corrosive attack on the contact area of the anodic part may be greatly intensified. Material selection for intermetallic contact parts, therefore, should establish the smaller part as the cathodic member of the couple.

A-3. PLATING

A-3.1 When base metals intended for intermetallic contact form couples not allowed by Table 2 they shall be plated with those metals which will reduce the potential difference to that allowed by Table 2.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2